

X-ray fluorescence imaging of biological model organisms trapped by laser-based optical tweezers

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Owing to its high sensitivity and non-destructive nature, synchrotron radiation based X-ray fluorescence computed tomography (SR XRF-CT) and confocal XRF imaging are emerging methods that provide three-dimensional (3D) information on elemental distributions with trace level detection limits. We propose a new methodology that combines these techniques with optical tweezers (OT) based non-contact sample manipulation for non-destructive micro/nano XRF imaging. In short, optical tweezers use a focused laser beam for trapping a sample within an aqueous environment, enabling non-contact sample manipulation and positioning (Figure 1). The objectives of the new methodology involve the investigation of free-standing biological samples in their natural, aqueous environment. This will lead to the study of organisms close to their natural *in-vivo* state, eliminating the time-consuming and error prone sample preparation steps. In addition, OT setups have the ability to work with multiple optical traps enabling XRF tomography via *in-vivo* sample rotation.

In 2011, Santucci *et al.* reported on the development of a dedicated OT setup for SR probing of trapped biological objects in their natural, aqueous environments [1]. During the past two years, the compact OT setup was further optimised and several biological model organisms were tested for their trapping capabilities. Within a pilot experiment in December 2012, the use of an appropriate sample container with the correct dimensions/composition was evaluated at beamline ID13 of the ESRF. These experiments showed that a cylindrical glass capillary container (200 μm diameter and 10 μm wall thickness, CTS Ltd., UK) is suitable for holding a micro-sample without considerable self-absorption and X-ray scattering effects (Figure 2). In June 2013, a second experiment was performed at beamline ID13 during which the optical tweezers technology was combined with SR micro-XRF *for the very first time*. During this experiment, *Chlamydomonas* sp. that were exposed to high metal concentrations were manipulated and kept stable using the compact optical tweezers setup and at the same time scanned with SR micro-XRF. The first results from this novel combination of optical tweezers/micro-XRF methodology will be reported in this presentation.

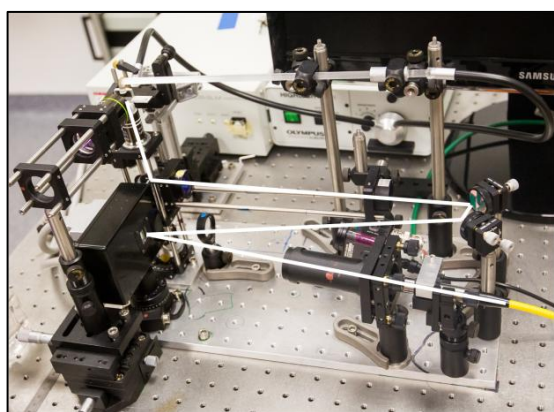


Figure 1: Compact optical tweezers setup with an indication of the laser beam path.

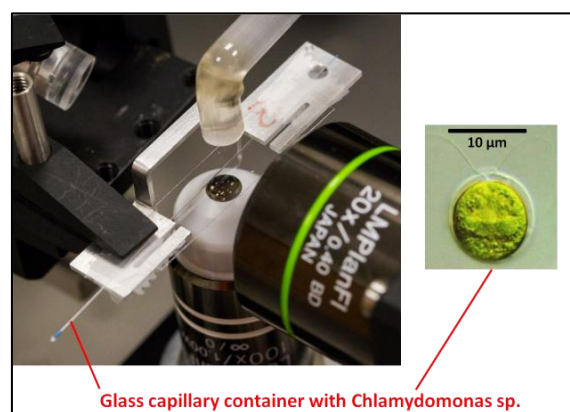


Figure 2: Detail of the sample environment showing a glass capillary filled with *Chlamydomonas* sp.

References

- [1] S.C. Santucci, et al., Analytical Chemistry **83**(12), 4863-4870 (2011).

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